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COMMUNICATION IN MILLIMETRIC WAVE BAND,(U)

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COMMUNICATION IN MILLIMETRIC WAVE BAND

by

V. M. Dmitrachenko

FOREIGN TECHNOLOGY DIVISION

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М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α α		Nu	Ν ν
Beta	Β β		Xi	Ξ ξ
Gamma	Γ γ		Omicron	Ο ο
Delta	Δ δ		Pi	Π π
Epsilon	Ε ε ϵ		Rho	Ρ ρ ϱ
Zeta	Ζ ζ		Sigma	Σ σ ς
Eta	Η η		Tau	Τ τ
Theta	Θ θ ϑ		Upsilon	Υ υ
Iota	Ι ι		Phi	Φ φ ϕ
Kappa	Κ ϰ κ		Chi	Χ χ
Lambda	Λ λ		Psi	Ψ ψ
Mu	Μ μ		Omega	Ω ω

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
sin	sin
cos	cos
tg	tan
ctg	cot
sec	sec
cosec	csc
sh	sinh
ch	cosh
th	tanh
cth	coth
sch	sech
csch	csch
arc sin	$\sin^{-1}$
arc cos	$\cos^{-1}$
arc tg	$\tan^{-1}$
arc ctg	$\cot^{-1}$
arc sec	$\sec^{-1}$
arc cosec	$\csc^{-1}$
arc sh	$\sinh^{-1}$
arc ch	$\cosh^{-1}$
arc th	$\tanh^{-1}$
arc cth	$\coth^{-1}$
arc sch	sech^{-1}
arc csch	csch^{-1}

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rot	curl
lg	log

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COMMUNICATION IN MILLIMETRIC WAVE BAND.

V. M. Dmitrachenko.

Page 62.

At present in many countries work proceeds on the creation of means of communication/~~connection~~ in millimetric wave band. The main reason for considerable attention to millimetric range is a possibility of designing of the broadband and super wide-band lines for the transmission of high-speed information in digital form, which possess a good freedom from interference and large electromagnetic compatibility with the existing radio-electronics systems.

Are develop~~/processed~~ed three fundamental new communications in millimetric wave band: super-multichannel waveguide lines, radiorelay lines and satellite lines. Is investigated the possibility of the optimum use of these lines on ~~grid/~~network. For example, for the national systems of satellite communication~~/connection~~ is expedient the application~~/use~~ of waveguide lines for a reception~~/procedure~~ on in

spaced up ~~the divorced~~ to 20-30 km (radius of the correlation of the spatial distribution of rainfall intensity) ~~of~~ antennas. The links of this range, besides independent value, can be utilized for a redundancy, with serious emergencies, waveguide lines. In ~~During~~ the composite use of the means indicated is possible the construction of ~~grid~~ network with the minimum use of terminal equipment for the coupling of ~~the~~ linear circuits of these means.

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By selecting the same values of the carrier frequencies of the radio trunks and some speeds of transmission, it is possible to produce the couplings of linear channels ~~circuits~~ directly in working frequency band.

For the developing integral communication networks is developed ~~processed~~ the large complex of equipment for transmission and commutation of information, transmitted in digital form. It is known that the fundamental form of modulation is accepted as ~~im~~pulse-code ~~coding~~ modulation (PCM [ИКМ - pulse-code modulation]). Are created and are operated in a number of the countries ~~of a~~ systems of the type IKM-12, IKM-24, IKM-30. Are developed ~~processed~~ systems of the type IKM-120, IKM-480, IKM-1000. Is created universal system PCM for the transmissions of all forms of information with capacity from 240 to ~~that~~ 960 Mbit/s.

The working pulse duration at such rates lie~~/rests~~ within limits of 1-5 ns. For the undistorted transmission of such ~~momentum/impulse/~~pulses the passband of linear circuit must be of order of 250-500 MHz, and on the radio-spectrum - on the order of 500-1000 MHz. Actually this band can be obtained either with ~~During~~ the use of coaxial cables, or with ~~during~~ the use of a millimetric range of waves ~~will.~~.

In ~~During~~ the transmission of such narrow pulses on coaxial cables the length of repeater section is decreased ~~descends~~ to 1-1.5 km, sharply ~~grow/~~rises the number of regeneration amplifiers, lowers ~~descends~~ the reliability of channel ~~circuit~~, is raised its cost.

In the millimetric wave band means of ~~of~~ communications ~~they~~ can have the following fundamental characteristics.

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(1) **Волноводные линии связи (ВЛС)**

(2) Диапазон рабочих частот . . .	(3) 30—100 *Ггц* (5)
(4) *Ширина полосы радиоствола* .	300 ÷ 1000 *Мгц*
(6) Число дуплексных радиостволов	(6a) до 30
(7) Пропускная способность одного радиоствола	(8) до 10 000 эквивалентных ТФ каналов
(9) Общая пропускная способность линии	(10) до 250 000 телефонных каналов
(11) Передача информации в цифровой форме:	
(12) — со скоростью	(13) от 100 до 960 *Мбит/сек*
(14) — с вероятностью ошибки . .	(15) не более 10^{-6}
(16) Направляющая среда — круглый волновод на волне типа H_{01} с затуханием	(17) 2 ÷ 3 *дб/км*
(18) Длина усилительного участка . .	15 ÷ 20 *км*
(19) Вид модуляции несущей , . . .	ИКМ-АМ, ИКМ-ФРМ
(20) Мощность передатчика	0,1 ÷ 0,5 *вт* (21)
(22) *Фактор шума приемника* . . .	10 ÷ 12 *дб* (23)
(23) Отношение сигнал/шум при ошибке не более 10^{-6}:	
(24) — для ИКМ-АМ	(25) не менее 23 *дб* (23)
— для ИКМ-ФРМ . . . . (24)	не менее 15 *дб* (23) (25)

(26) **Радиолинейные линии связи (РРЛ)**

(2) Диапазон рабочих частот . . .	(3) 36—40 *Ггц* (5)
(4) Ширина полосы радиоствола . .	300 ÷ 500 *Мгц*
(6) *Число дуплексных радиостволов* .	(6a) до 5 ÷ 6
(7) Пропускная способность одного радиоствола	(8) до 5000 ТФ каналов
(9) Общая пропускная способность линии	до 20 000 ТФ каналов (27)
(11) Передача информации в цифровой форме:	
(12) — со скоростью	(13) от 100 до 480 *Мбит/сек*
(14) — с вероятностью ошибки . .	(15) не более 10^{-6}
(18) Длина усилительного участка:	
(28) — 8—10 *км без пространственного* разноса станций	
(29) — 15—20 *км* с пространственным разносом	(6a) до 20—30 *км* (30)
(19) Вид модуляции несущей . . .	ИКМ-ФРМ, для однопролетных линий можно использовать ЧМ

(20) Мощность передатчика	0,3—1 *вт* (21)
(22) Фактор шума приемника . . .	10—12 *дб* (23)
(31) Отношение сигнал/шум при ошибке не более 10^{-6} для ИКМ-ФРМ (23) не менее 25 *дб*	(32)
(34) Антенна:	диаметр 1,5—2 *м* (33) усиление 50—60 *дб* (23) (36) высота 30—50 *м*
(35) Источники питания (37) (при отсутствии близких ЛЭП) .	(38) термогенераторы с подогревом от газа

Key: (1). Waveguide lines of communication/~~connection~~ (VLS). (2). Operational frequencies band. (3). GHz. (4). Width of the band of radio trunk. (5). MHz. (6). Number of duplex radio trunks. (6a). to. (7). The capacity of one radio trunk. (8). to 10000 equivalent TF channels. (9). ~~General~~ Total capacity of line. (10). to 250,000 telephone channels. (11). Transmission of information in digital form. (12). with speed. (13). from 100 to 960 Mbit/s. (14). with the probability of error. (15). ~~it is~~ not more than. (16). Directing medium ~~is~~ circular waveguide on a wave of the type H_{01} with attenuation. (17). dB/km. (18). Length of repeater section. (19). the form of carrier modulation. (20). Power of transmitter. (21). W. (22). Signal-to-noise ratio, with error ~~is~~ of not more than. (23). dB. (24). for. (25). ~~it is~~ not less than. (26). Radio-linear lines of communication/~~connection~~ (RRL [99sp03 - radio relay line]). (27). to 5000 TF channels. (28). 8 - 10 km without the ~~three-dimensional~~/space separation of stations. (29). 15-20 km with ~~three-dimensional~~/space separation. (30). for single-span lines it is possible to utilize FM. (31). Signal-to-noise ratio with error ~~is~~ of not more than 10^{-6} for IKM-FRM. (32). diameter. (33). amplification. (34). Antenna. (35). Power supplies. (36). height/~~altitude.~~ of 30-50 m (37). (in the absence of close LEP). (38). thermal converters with preheating from gas.

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Equipment can be ~~arrange/~~ located or on mast or below.

For antenna feed it is possible to use ~~plumbing~~ waveguide channel in wave H_{01} with complete attenuation of not more than 2-3 dB ~~by~~ at 100 m.

Communicating systems through ISZ [~~99sp03~~ ИСЗ - artificial earth satellite].

It is known that the communicating systems through ISZ are divided into global and local. Millimetric wave band is assumed to utilize for all forms of communication through ISZ. For example, firm Bell proposed the project of super-multichannel satellite system with the use of a series of the low-flying satellites. Is carried out at present experiment in millimetric range on satellite ~~at SHEH,~~ AT-5, is plan~~glide~~ned experiment with satellite ~~at~~ AT S-F. Experiment and the calculations show that it is possible to expect the following parameters of the line through ISZ in millimetric wave band ~~at~~ with the transmission of the digital information:

(1) Диапазон рабочих частот Земля — спутник	(2) 29—31 *Ггц*
(3) Диапазон рабочих частот спутник — Земля	(2) 40—41 *Ггц*
(4) Для обоих направлений возможно использовать	(2) 36—41 *Ггц*
(5) Ширина полосы радиоствола .	(8) до 500 *Мгц* (6)
(7) Число стволов	(8) до 4—5
(9) Пропускная способность одного ствола	(8) до 5000 ТФ каналов (10)
(11) Передача цифровой информации со скоростью	(12) от 100 до 480 *Мбит/сек* (13)
(14) Вид модуляции несущей	ИКМ-ФРМ
(15) Мощность передатчика спутника .	2—5 *вт* при диаметре антенны (16) 10 *м* и порядка (17) 40 *вт* при диаметре 2,5—3 *м* (18)
(19) Коэффициент шума приемника спутника	8—10 *дб* (20)
(21) Мощность передатчика наземной станции	1 *квт* при диаметре антенны 10 *м* (22)
(23) Температура шума приемника наземной станции	(24) порядка 200°К

Key: (1). Operational frequencies bands ~~the~~ of Earth - satellite. (2). GHz. (3). Operational frequencies bands ~~the~~ of satellite - ~~the~~ Earth. (4). For both directions it is possible to utilize. (5). Width of the band of radio trunk. (6). MHz. (7). Number of trunks ~~shafts.~~ (8). to. (9). The capacity of one trunk ~~shaft.~~ (10). channels. (11). Transmission of digital information with speed. (12). from. (13). Mbit/s. (14). Form of carrier modulation. (15). Power of the transmitter of satellite. (16). 2-5 W with the diameter of antenna. (17). 10 m order. (18). 40 W with diameter 2.5-3 m. (19). Coefficient of receiver noise of satellite. (20). dB. (21). Power of the transmitter of ground station. (22). 1 kW with the diameter of antenna 10 m. (23). Noise temperature~~s~~ of the receiver of ground station. (24). order 200°K.

In such averaged parameters of system and for the ~~middle~~ average climatic zone (average intensity of rainfall - 5 mm/h) supplementary gain reserve ~~margin~~ must be not less than 15-20 dB. Without this reserve the communication line can be disabled up to 40 h per annum. However, the application ~~use~~ of the diverse reception ~~procedure~~ on the order of 20-30 km in distance lowers time of unfitness for operation ~~work~~ to 10-20 min per annum.

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Technical bases of the creation of the millimetric lines.

Contemporary radio-electronics industry virtually mastered and approached toward the issue of active and passive ~~equipment/~~devices of millimetric range, on the basis of which it is possible to create the millimetric communication lines with the parameters indicated.

In many countries for the waveguide communication lines are developed special circular waveguides on wave H_{01} with attenuation in range 30-100 GHz on the order of 2-3.5 dB/km. On their basis are constructed and tested experimental lines up to 20 km long. Plan~~/glides~~ned is the construction of waveguide lines with length up to several hundreds of kilometers.

Are developed ~~the specimen/samples~~ models of transceivers for amplification and regeneration in the millimetric wave band of signals IKM-FRM at rate to 960 Mbit/s. These transceivers are created with the application~~/use~~ of the newest semiconductors SHF [~~99sp03~~ CBY - superhigh frequency] and integral SHF ~~equipment/~~devices: avalanche-and-transit diodes, diodes on the effect of Hann, diodes with the barrier of Schottky, micro~~track~~band circuits, etc. Are developed also tubes with the traveling wave at power up to several dozen watte.

Is created ~~by the~~ gamm~~a~~et of very high speed integrated circuits with operating speed more than 200 MHz. On their basis are developed the s~~pecimen/samples~~ models of terminal equipment with ~~im~~pulse-cod~~ing~~ modulation for the transmission of the different forms of information.

Are constructed and tested ~~the~~ experimental radiorelay lines ~~lines~~ of millimetric with throughput ups ~~s-band~~ capacit~~y~~ to of several thousand equivalent telephone channels. Are investigated the statistic~~ian~~s of the ~~three-dimensional~~/spa~~ce~~tial and time/~~temporary~~ distribution of the rains, which determine fading of signal and, therefore, the fundamental parameters of the lines.

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